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THE SPATIAL THRESHOLD OF TOUCH IN BLIND AND IN SEEING CHILDREN

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There have been diverse reports by experimenters upon the tactile sensitivity of the blind. An account of the earlier work will be found in the elaborate study by Griesbach,[2] and need not here be repeated, save to say that while some, notably Czermak, Gärtner, and A. Stern, had found the blind to be superior to the seeing in the tactile discrimination of space—the 'two-point threshold'—Uhthoff had found no difference between the two kinds of individuals. Griesbach's own experiments, on the contrary, led him to believe not only that there was a difference, but that, slight though it was, it was to the disadvantage of the blind. Some experiments by Miss Bunnell and Miss Stowell, reported by one of the present writers,[3] had supported the earlier position that the blind were slightly superior. Finally in this field of tactile space Seashore and Ling [4] found that the threshold for the blind was neither lower nor higher than for the seeing, although the seeing had a somewhat greater variability than had the blind.

The reason for such diversity of finding perhaps lies in the fact that the conditions under which the experiments were conducted were by no means uniform. The kind of æsthesiometer used, the amount of pressure exerted upon the skin, the fatigue, the degree of attention given, the chance suggestions received—all these are important modifying factors.

[1] From the Psychological Laboratory of the University of California. The writers are indebted to Dr. Warner Brown and to Dr. R. S. French for invaluable assistance in this study.

[2] H. Griesbach, 'Vergleichende Untersuchungen über die Sinnesschärfe Blinder and Sehender.' *Archiv. f. d. gesam. Physiol.*, 1899, Vol. 74, pp. 577–638; Vol. 75, pp. 365–429, 523–573.

[3] Stratton, 'Experimental Psychology,' 1903, p. 46.

[4] C. E. Seashore and T. L. Ling, 'The Comparative Sensitiveness of Blind and Seeing Persons.' Psych. Mon., Vol. 25, 148–158.

progression, including the feelings which, apparently, are inseparably attached thereto. Assuming that the musically talented have a 'sense' of consonance, and since the object of this test is to determine and point out such musical talent, from the very nature and structure of the test material, there is reason to expect negative results from the talented group.

All of which raises a very pertinent question—a question which needs to be considered in the light of musical history and of modern musical tendencies, and which must be left unanswered until more extensive and intensive investigations have been carried out; namely, is a sense of consonance [7] a fundamental and necessary factor of the 'musical mind'?

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[7] That is, what Seashore and his collaborators mean by the term 'consonance.'

Only in the work of Seashore and Ling was there care that the seeing and the blind should be of approximately equal intelligence; and yet even here the age was not kept fairly equal, for the blind were older than the seeing. And in none of the work does there seem to have been any attention given to the consistency of the findings—the 'reliability,' so-called, of the tests. It is therefore clear that in the field of space-perception by the blind there is both opportunity and need of further work.

I. The Method

In planning the experiment, an effort was made to avoid certain sources of error which are easily present in testing for the two-point and pressure thresholds by the ordinary method. Of these errors, suggestion, and the strain involved in waiting for the contrasts are probably the worst. They seemed particularly undesirable with subjects who are already handicapped in sensory equipment. The chief effort, therefore, was to find a means of testing for these thresholds which would do away with suggestion, and which would lessen the strain of expectation. If it were possible to have the blind work in a way to which they were accustomed, it would decrease these undesirable factors.

To accomplish this end a method was adopted which permitted the child to choose his own time and rate of touching the points; a method which used, instead of trying to inhibit, the tendency to move the fingers when making fine tactual discrimination; and which, by the essentials of the method of serial groups [1] reduced greatly the influence of suggestion. An æsthesiometer was made, having many raised points, over which the subject ran his finger, as over a page of Braille. The points were arranged in rows, the rows an inch apart; and in the rows there were irregular alternations of single points and of pairs of points, the two points of each pair being set at varying but accurately measured distances apart. In any given row there were as many single points as there were pairs. And these were spaced, also an inch apart, so that

[1] Stratton, 'The Method of Serial Groups,' *Psych. Rev.*, IX., 444.

there were rows along the board either lengthwise or crosswise. As the subject moved his finger along from left to right, the distance between the two points of such pairs as occurred in the row decreased, discrimination growing increasingly difficult. These points were, in reality, tiny steel posts raised 3 mm. uniformly above a solid smooth surface, each post being .34 mm. in diameter, made of a No. 12 Milward needle cut off squarely at the top and polished. These were set with precision by an expert instrument maker, the distances being computed from the centers of the posts. There were, in all, eighteen pairs of points, forming a series decreasing from the most distant, which were 2 mm. between the points, to the least distant, which were 0.3 mm. apart, the decrease being by 0.1 mm. as one passed from pair to pair.

It was desirable that all the subjects put forth their best efforts throughout the tests; and to accomplish this end, it was decided that competition should be introduced, by offering prizes for the best scores. Three prizes were given for the best scores on the first sitting, and three for the second sitting. The children were tested individually but the competition was within each of several groups: of the blind children, those of the fourth, fifth, and sixth grade forming one group, and those of the seventh, eighth, and ninth grade forming another; the control subjects, the seeing children, formed the third group. Thus each group received a prize.

The blind children tested were thirty-five in number, from the California State School for the Blind. These were all the available children in the regular classes from the fourth through the ninth grade, between the ages of twelve and eighteen. Intelligence scores were available for twenty-four of the thirty-five blind subjects. By this means, and since only those children were taken who were doing regular work, it was possible to eliminate those of low intelligence, such as might be found in the special classes of the school.

The blind children thus selected were next classified into five degrees of sight which were determined by simple tests, with care always for intense and equal illumination.

Degree 1, was total loss of vision. The organ of sight was

frequently lacking in these subjects. No light whatever could be seen.

Degree 2 meant the power to distinguish between light and darkness, but not to recognize the form of objects. Strong sunlight reflected directly into the subject's face from a sheet of glazed white cardboard elicited the response 'lighter,' while exposure of a black sheet in the same position brought forth the response 'darker.' In no case was the subject able to perceive the shape of the object used as a reflector.

Degree 3 meant only the coarsest vision for the form of objects. A sheet of glazed white cardboard 56 cm. square was used, with a band 20 cm. wide and 56 cm. long extending across the middle of the sheet. The cardboard was held vertically 1 meter from the subject's face, and the subject was required to judge whether the black band extended vertically or horizontally across the white sheet. Out of three trials, all judgments were required to be correct.

Degree 4 required that the subject be able to describe with general correctness the appearance of a 56-cm.-square sheet of paper held 1 meter away, the face of which was divided into halves, the one half being entirely of a uniform gray; and the other half, bearing a checker-board design of alternate black and white squares, each square with sides of 5 cm.

Degree 5 required that the subject be able, by sight, to distinguish large letters. Printed letters 1¼ inches in height were used. The subject was required to name the letters, or read the word before him. Some of these subjects could read normal print held close to the eyes but none could read it at a distance of 14 inches. The children in this group were able to read Braille characters, not only by touch, but visually. Some of these children, upon occasion, bring their eyes close to the page of Braille, as if visually to supplement their tactile perception of it.

Since the blind children were under institutional care, it was deemed advisable to choose the seeing children likewise from an institution. Accordingly, for comparison, fifteen girls from the Roman Catholic Orphan Asylum in San Francisco were selected and these girls were between the ages

of twelve and seventeen, and between the fifth and the tenth grades, inclusive. Intelligence scores in their case were not available, but no girl was chosen who was not making normal scholastic progress, or who gave evidence of maladjustment or incorrigibility. From these normal children, the experimental group of fifteen was selected at random by the Sister in charge, with age requirements chiefly in mind. The two groups were therefore approximately equal in age, school, and living conditions.

All tests were given by the same experimenter. The blind children were tested between 8:00 A.M. and 1:00 P.M. The seeing children were tested between 9:00 A.M. and 4:00 P.M. Each subject had three sittings: a preliminary sitting, in which he became accustomed to the apparatus, the procedure, and the experimenter, and was told something of the purpose of the test. Record was made only of the next two sittings, which were always at least four days apart.

The subjects, as was said, were tested individually. They were permitted to use the index finger of the preferred hand. Of the blind, this was the right hand in thirty-four out of the thirty-five cases. Of the seeing, it was always the right hand. The seeing children were blindfolded for both sittings. The blind children were never blindfolded, but were placed so that the instrument was out of their range of vision.

The directions to the subjects were as follows: "I have here a board in which are placed some little steel posts. They are set in two long rows down the board. They also form short rows across the board. Sometimes there is one post, and sometimes there are two near together, but never more than two. I want you to tell me how many you feel in position—whether one or two. Take them across this way first." The subject was required to take the rows across the board on the odd runs down the board, and to take the rows longitudinally on the even runs. This prevented his becoming familiar with the position of the pairs. Portions of the board which a subject gave correctly several times were omitted for him in later runs; that is, if he always recognized the upper five pairs correctly, he was no longer required to

give judgment upon the upper two or three of these pairs. If he always was in error below a certain position, then the lower of these pairs were dropped out.

By this procedure, each sitting yielded from each subject ten judgments for each separation of the two points. The threshold was arbitrarily fixed as the least separation at which 80 per cent. of the judgments for any given subject were correct. Provision was made for exceptions to this rule. Occasionally errors were made in judging points much farther apart than those at which the errors began to appear consistently. If no one of the three degrees of separation next lower than this single case gave more than two errors, then the errors made in judging the greater degree of separation were disregarded. An example will make this clear. One observer made no error in judging points 2.0 mm. apart, and no error with points 1.9 mm. apart; at 1.8 he made four errors; but in the series of distances from 1.7 to 1.0 he in no case made more than two errors. At 0.9 mm. he made four errors; at 0.8 mm. four errors; at 0.7 mm., seven errors; and three or more errors at each smaller distance than this. His threshold was set down as at 1.0 mm. and not as at 1.8 mm., which a strict application of the rule would have required.

The blind subjects were found, by the tests indicated, to be distributed as follows, among the several degrees of sight.

	Degrees of Sight				
	I	II	III	IV	V
Boys	6	3	0	1	6
Girls	4	6	1	0	8
Total	10	9	1	1	14

In the comparison to be reported hereinafter, between the tactual space of those of different degrees of blindness, the degrees III. and IV. are disregarded because the number of individuals in them is so small. The 19 subjects in degrees I. and II. who can see no shape whatever were regarded as

totally blind, while the 14 subjects in degree V. were regarded as partially blind.

From these two groups, in order to bring out possible differences, separate statistical attention was given to those totally blind from birth, of whom there are eight, and those partially blind from birth, of whom there are eleven.

II. The Results

To obtain the coefficient of reliability of the test itself the scores obtained for each subject in the first sitting were compared with the scores of these same individuals in the second sitting.

The coefficient of correlation between the two sittings indicated that the test gave a reliable measure of the spatial threshold.

With the seeing group, there was a lower coefficient of reliability than with the blind. This may be due to the fact that the distances at the upper end of the æsthesiometer are too small to be an adequate measure for seeing children. The widest distance between points, it will be remembered, is 2.0 mm.

1. Two-Point Thresholds in Millimeters

Returns from the Two Sittings Given Separately

I. = First Sitting; II. = Second Sitting

Group	No. Cases	Mean I.	Mean II.	S.D. I.	S.D. II.	Correlation of Means I. and II.
Whole group of blind	35	1.20±.05	1.17±.06	.40	.50	+.76±.05
Seeing group	15	1.77±.05	1.70±.06	.26	.32	+.54±.12
Partially blind	14	1.36±.05	1.39±.08	.29	.44	+.62±.11
Totally blind	19	1.08±.08	0.97±.07	.37	.45	+.79±.06
Partially blind from birth	11	1.36±.06	1.37±.08	.27	.38	+.46±.16
Totally blind from birth	8	0.91±.07	0.91±.11	.27	.45	+.58±.16

2. Two-Point Thresholds in Millimeters

Returns from the Two Sittings Combined

Group	No. Cases	Means and P.E. of Mean	S.D. of Distribution
Whole group of blind	35	1.160±.049	.435
Seeing group	15	1.780±.049	.285
Partially blind	14	1.364±.068	.378
Totally blind	19	0.973±.064	.413
Partially blind from birth	11	1.355±.077	.377
Totally blind from birth	8	0.925±.088	.369

3. Entire Group of Blind

Means and Correlations of Age, School-Grade, and Two-Point Threshold for Both Sittings Combined

Age		School-Grade		Two-Point Threshold	
Mean	S.D. of Distr.	Mean	S.D. of Distr.	Mean	S.D. of Distr.
15.11	1.83	6.43	2.03	1.16	.435

Coefficients of Correlation

Age with school-grade ..... +.758
Age with two-point threshold ..... −.001
School-grade with two-point threshold ..... −.002
Partial Correl.: School-grade with two-point threshold when age is rendered constant ..... −.001

Two-Point Thresholds: Difference of Means of Such Groups as are Mutually Exclusive

	Seeing	Partially Blind	Partially Blind from Birth	Totally Blind	Totally Blind from Birth
Seeing		.41±.07	.42±.11	.69±.11	.86±.12
Partially blind	.41±.07			.29±.08	
Partially blind from birth	.42±.11				.44±.13
Totally blind	.69±.11	.29±.08			
Totally blind from birth	.86±.12		.44±.13		

(Above is for First Sitting)

Seeing		.31±.14	.32±.14	.73±.13	.78±.18
Partially blind	.31±.14			.32±.16	
Partially blind from birth	.32±.14				.46±.20
Totally blind	.73±.13	.32±.16			
Totally blind from birth	.78±.18		.46±.20		

(Above is for Second Sitting)

	Seeing	Partially Blind	Partially Blind from Birth	Totally Blind	Totally Blind from Birth
Seeing		.416±.084	.425±.092	.807±.080	.855±.101
Partially blind	.416±.084			.391±.093	
Partially blind from birth	.425±.092				.430±.116
Totally blind	.807±.080	.391±.093			
Totally blind from birth	.855±.101		.430±.116		

(Above is for Both Sittings Combined)

III. Conclusions

1. The measurements obtained in the two sittings are correlated with each other to a degree which indicates that the method employed gives consistent, *i.e.*, 'reliable,' results.

2. The differences between the means of those groups which are mutually exclusive are sufficiently large in comparison with the probable errors of the differences to warrant the conclusion that the differences themselves are significant and are not merely accidental or specious.

3. The spatial threshold of touch for the blind group as a whole is lower than for the group of those who have sight. And this advantage over those who can see holds true for each of the sub-groups of the blind, namely for the partially blind, the totally blind, the partially blind from birth, and the totally blind from birth.

4. The degree of the blindness affects the spatial threshold. The totally blind have a lower threshold than the partially blind.

5. Among the blind, the threshold does not significantly vary with grade in school. The fineness of tactual perception of space appears to be an insignificant factor in the blind child's progress in school.

6. The present findings are in accord with those of the earlier experiments in California, and of Czermak, Gärtner and others, who found the blind to be superior to the seeing in the tactile discrimination of space; and are opposed to those of Uhthoff, Griesbach, Seashore and others who found either that there was no difference in this respect, between the blind and the seeing, or that the tactual advantage was actually on the side of those who could see.